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1. Your reference P33608GB/JJH

2. 0216740.1

18 JUL 2002

19JUL02 E734437-6 D00056
P01/7700 0.00-0216740.1

3. Full name, address and postcode of the or of each applicant *(underline all surnames)*

Ricardo Consulting Engineers Limited
Bridge Works, Shoreham-by-Sea,
West Sussex, BN43 5FG.

Patents ADP number *(if you know it)* 68722800l

If the applicant is a corporate body, give the country/state of its incorporation

United Kingdom

4. Title of the invention

Self-testing Watch Dog System

5. Name of your agent *(if you have one)*

"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*

Kilburn & Strode
20 Red Lion Street
London
WC1R 4PJ

Patents ADP number *(if you know it)* 125001

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Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*

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Description	5
Claim (s)	3
Abstract	1
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11. I/We request the grant of a patent on the basis of this application.

Signature Juliet Hibbert Date 18/07/02

12. Name and daytime telephone number of person to contact in the United Kingdom

Hibbert, Juliet Jane Grace
Tel: 020 7539 4200

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Control System

This invention relates to a control system for a load such as a drive mechanism and in particular to a so-called "fail off" control system in which, when a fault is detected, the operation of the load is ceased or switched out.

Control systems generally include fault detection systems which control the operation of the control system when a fault is detected. There are three main types of control system with fault detection: "fail on", in which the mechanism associated with the control system is maintained in an "on" state if a fault is detected (commonly used in situations (e.g. aircraft) in which to turn the system off may result in fatal consequences); "fail off" in which the mechanism associated with the control system is put into an "off" state if a fault is detected (commonly used in situations (e.g. vehicle drive mechanisms) in which to leave the system on may result in fatal consequences); and "do nothing", in which the mechanism associated with the control system is maintained in its current state if a fault is detected and a log of a fault generated for later inspection and solution.

In accordance with the invention there is provided a control system for a load, the system comprising a first microprocessor having an output to provide a drive signal to drive the load, a second microprocessor to monitor the operation of the first microprocessor and the operation of the load, the system being arranged so that when the second microprocessor detects a fault in the operation of the first microprocessor and/or the operation of the load, the second microprocessor is arranged to switch out the load or halt the operation of the first microprocessor.

The system may further comprise a first driver controlled by the first microprocessor to drive the load and a second driver controlled by the second microprocessor to switch out the load.

The second microprocessor may be arranged to monitor the current output from the load.

The second microprocessor may be arranged to monitor the output from the first microprocessor and to detect if this output alters to become an input.

The microprocessor may be arranged to calculate the current of the load and, if the load current does not meet pre-determined criteria, to switch out the load.

In a further aspect of the invention there is provided a control method for a load, the method comprising driving a load by means of a drive signal provided by a first microprocessor, monitoring the operation of the first microprocessor and the operation of the load by means of a second microprocessor, when the second microprocessor detects a fault in the operation of the first microprocessor and/or the operation of the load, the second microprocessor switches out the load and/or halts the operation of the first microprocessor.

The invention will now be described, by way of example only, with reference to the accompanying drawing, in which:

Figure 1 is a first embodiment of a drive control system according to the invention.

Figure 1 shows a first embodiment of a drive control system according to the invention. A load 10 is driven by two drivers, a high side driver 12 and a low side driver 14. The operation of the drivers 12, 14 is controlled by a first

microprocessor 16. For safety reasons a second microprocessor 18 is provided to monitor the operation of the drive control system. The drivers 12, 14 may take any suitable form e.g. MOSFET switches or the like. The drivers 12, 14 may drive the load 10 by various means such as a Pulse Wave Modulation (PWM) signal or the like.

Two microprocessors are provided to ensure a fail-safe operation of the drive control system. In normal operation, the main microprocessor 16 controls the high side driver 12 (the low side driver 14 normally being switched on) and monitors the operation of the load by monitoring the low side of the load 10 at point A.

Each microprocessor 16, 18 has programmed into it a set of rules by which the operation of the load is controlled. The set of rules of the second microprocessor 18 may be identical to the set of rules of the first microprocessor. Alternatively, the set of rules of the second microprocessor 18 may be coarser than or a subset of the set of rules of the first microprocessor.

In use, the second microprocessor monitors the operation of the first microprocessor 16 and the operation of the load 10 to determine if the system is operating according to the set of rules of the second microprocessor. If either is not operating according to the set of rules of the second microprocessor, the microprocessor switches out the load 10 by means of setting the low side driver 12 to open. Thus the load no longer has any effect on other systems.

In a preferred implementation of the invention, the second microprocessor monitors each of the outputs of the first microprocessor individually to monitor for faults with the main microprocessor 16. In the embodiment shown in Figure 1, this may be achieved by means of resistors R1, R2 and R3.

Each time a microprocessor is powered up, the microprocessor is reset which usually involves most, if not all, of the pins of the microprocessor being set to inputs. The programming of the microprocessor then resets the pins to their required state for proper operation. If the microprocessor incorrectly sets a pin to be an input rather than an output (or vice versa) clearly a fault with the microprocessor will exist.

In the arrangement shown in Figure 1, resistor R1 is connected to the pin from the main microprocessor 16 which is connected to the high side driver 12. Resistor R1 prevents the high side driver 12 being driven when the pin is incorrectly set as an input pin, for instance when the microprocessor 16 is reset. This is achieved by the monitor microprocessor 18 which monitors the output of the pin via R1 and if the voltage changes from a voltage allowable on an output pin to one that is not allowable on an output pin, the monitor microprocessor 18 detects this and recognises this as a fault.

In the arrangement of Figure 1 resistors R2 and R3 operate together to ensure that if the output pin of the main microprocessor that is connected to the high side driver 12 switches to become an input pin, then the both the high and low side drivers 12, 14 are switched to open and the effect of the load switched out. Resistor R2 is connected between the ground rail and the output pin of the main microprocessor that is connected to the high side driver 12. R3 is connected between the ground rail and the output pin of the monitor microprocessor that is connected to the low side driver 14.

The control system also includes a current sensor 20. This in itself may be a potential fault source since if it fails then the microprocessors are unable to detect this failure. This may be overcome by providing two current sensors in

series. Alternatively, in a preferred embodiment of the invention, a back-up to the current sensor is provided by the monitor microprocessor which calculates the current from the power supply voltage and the resistance of the load 10 by means of the equation I = V/R. This may also be achieved by monitoring the voltage at the high side driver and the voltage at the low side driver, calculating the voltage drop across the load and, knowing the resistance of the load, calculating the load current.

The results of the calculation may then be compared with the output of the current sensor 20 and if the difference between the two meets predetermined criteria (e.g. is less than or equal to a pre-determined threshold), then the monitor microprocessor detects a fault with the current sensor and either switches out the load as a result (for a fail off system) or logs the fault for subsequent consideration. In the latter case, the control system would then rely on the current calculation to monitor the current which may not be desirable, depending upon the type of load and/or the field of application of the load.

The control system shown is applicable to many areas where the control of a drive is required. The invention has particular application to a gear control system, for instance as used in a vehicle, but this is not intended to be limiting. In the field of vehicular gear control systems, the load 10 may be a gear box selector, a clutch selector, a valve in a pneumatics system etc.

Claims

1. A control system for a load, the system comprising a first microprocessor having an output to provide a drive signal to drive the load, a second microprocessor to monitor the operation of the first microprocessor and the operation of the load, the system being arranged so that when the second microprocessor detects a fault in the operation of the first microprocessor and/or the operation of the load, the second microprocessor is arranged to switch out the load or halt the operation of the first microprocessor.

2. A system according to claim 1 further comprising a first driver controlled by the first microprocessor to drive the load and a second driver controlled by the second microprocessor to switch out the load.

3. A system according to claim 1 or 2 wherein the second microprocessor is arranged to monitor the current output from the load.

4. A system according to claim 1, 2 or 3 wherein the second microprocessor is arranged to monitor the output from the first microprocessor and to detect if this output switches to become an input.

5. A system according to any preceding claim wherein the microprocessor is arranged to calculate the current of the load and, if the load current does not meet pre-determined criteria, to switch out the load.

6. A system according to any preceding claim wherein the control system is a vehicular control system.

7. A system according to any preceding claim wherein the load is a gear box selector, a clutch selector or a valve.

8. A control method for a load, the method comprising driving a load by means of a drive signal provided by a first microprocessor, monitoring the operation of the first microprocessor and the operation of the load by means of a second microprocessor, when the second microprocessor detects a fault in the operation of the first microprocessor and/or the operation of the load, the second microprocessor switches out the load and/or halts the operation of the first microprocessor.

9. A method according to claim 8 further comprising driving the load by means of a first driver controlled by the first microprocessor and switching out the load by means of a second driver controlled by the second microprocessor.

10. A method according to claim 8 or 9 further comprising monitoring the current output from the load by means of the second microprocessor.

11. A method according to claim 8, 9 or 10 further comprising the second microprocessor monitoring the output from the first microprocessor to detect if this output alters to become an input.

12. A method according to any of claims 8 to 11 further comprising calculating the current of the load and, if the load current does not meet pre-determined criteria, switching out the load.

13. A method according to any of claims 8 to 12 wherein the control method is applied to a vehicular control system.

14. A method according to any of claims 8 to 13 wherein the load is a gear box selector, a clutch selector or a valve.

ABSTRACT

CONTROL SYSTEM

A control system for a load (10), the system comprising a first microprocessor (16) having an output to provide a drive signal to drive the load, a second microprocessor (18) to monitor the operation of the first microprocessor and the operation of the load (10), the system being arranged so that when the second microprocessor (18) detects a fault in the operation of the first microprocessor (16) and/or the operation of the load (10), the second microprocessor is arranged to switch out the load (10) or halt the operation of the first microprocessor (16).

Fig. 1

Fig. 1